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National Aeronautics and Space Administration

Human Research Program

Advanced Exercise Concepts (AEC) Overview

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Human Research Program Investigator's Workshop

Advanced Exercise Concepts (AEC) Overview

- The current ISS suite of exercise countermeasures hardware is a vast improvement over previous generations of equipment, **however** vehicle constraints for future exploration missions beyond LEO will not be able to accommodate the size and mass of these ISS-class devices

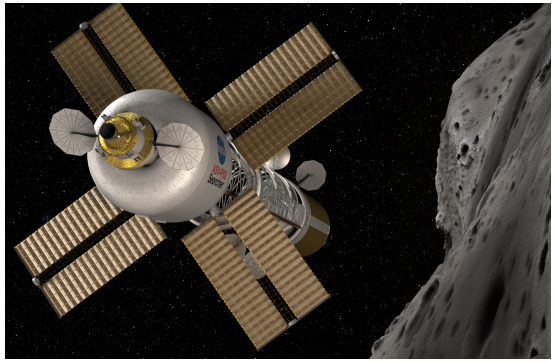
Advanced Exercise Concepts (AEC) Overview

- The current ISS suite of exercise countermeasures hardware is a vast improvement over previous generations of equipment, **however** vehicle constraints for future exploration missions beyond LEO will not be able to accommodate the size and mass of these ISS-class devices

- Smaller but similarly capable exploration-class exercise devices will be required to support exploration-class exercise countermeasures regimens and functional performance requirements of the crew

- The Human Research Program (HRP) is managing AEC **requirements development** and **candidate technology maturation** for all DRMs from MPCV EM-2 (up to 21 day) to Mars Transit (up to 1000 day) missions

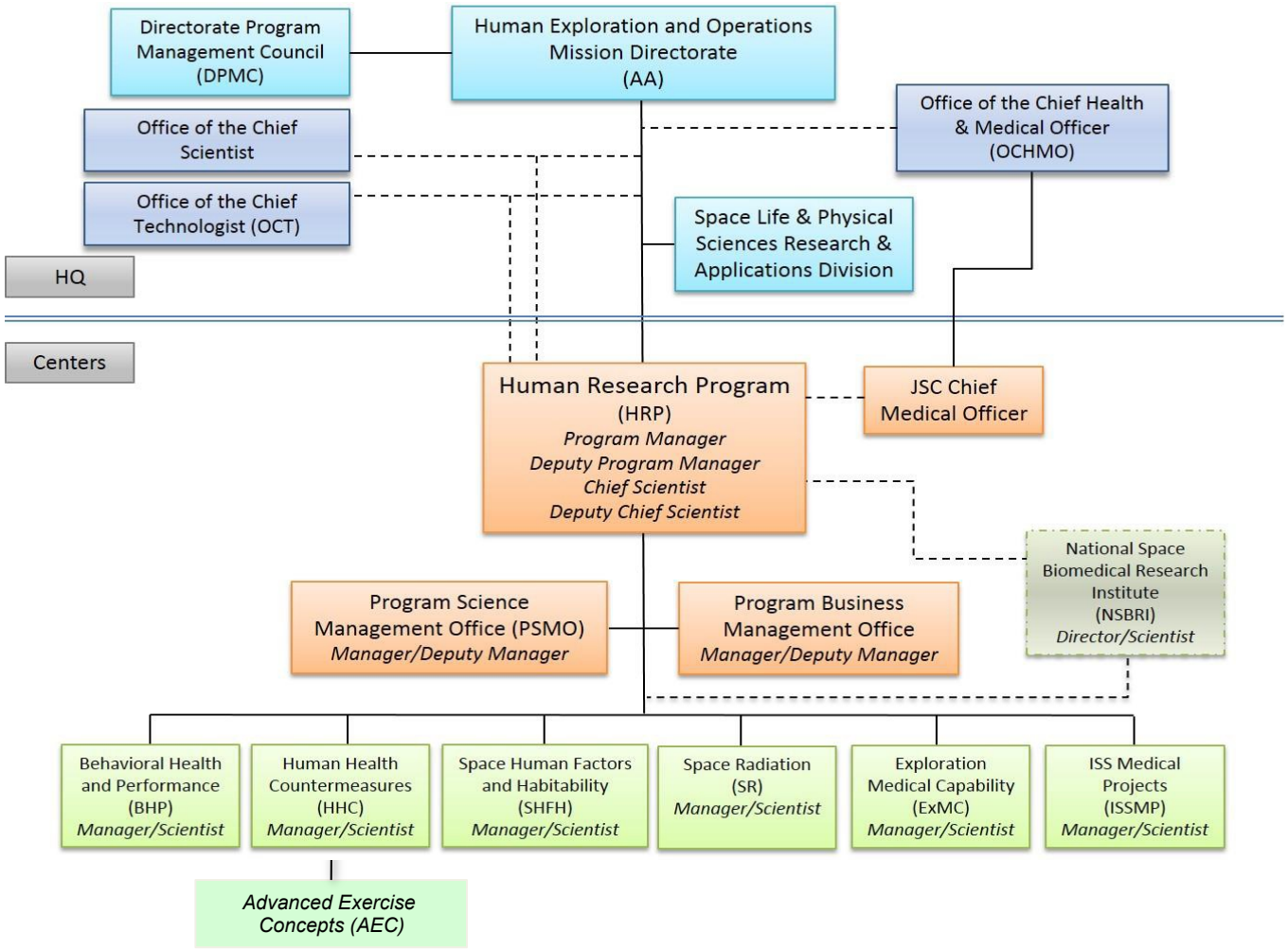
Multi Purpose Crew Vehicle Exploration Mission EM-2



Asteroid

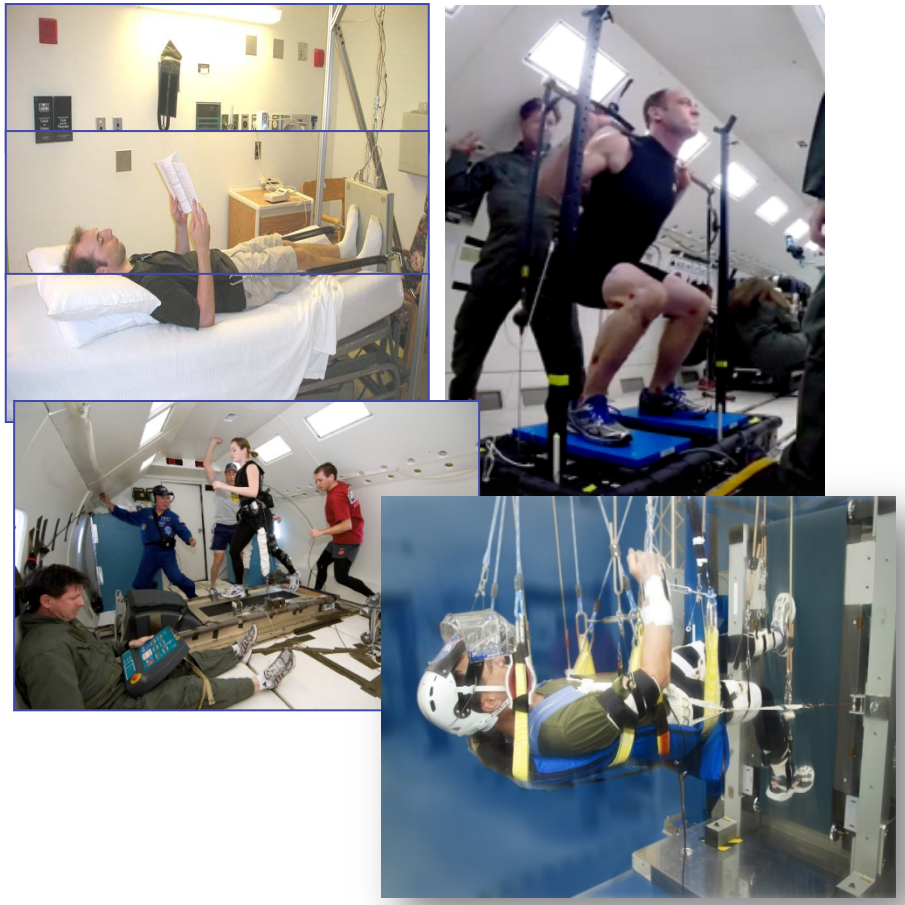
Mars Transit Vehicle

HRP Organization – Advanced Exercise Concepts

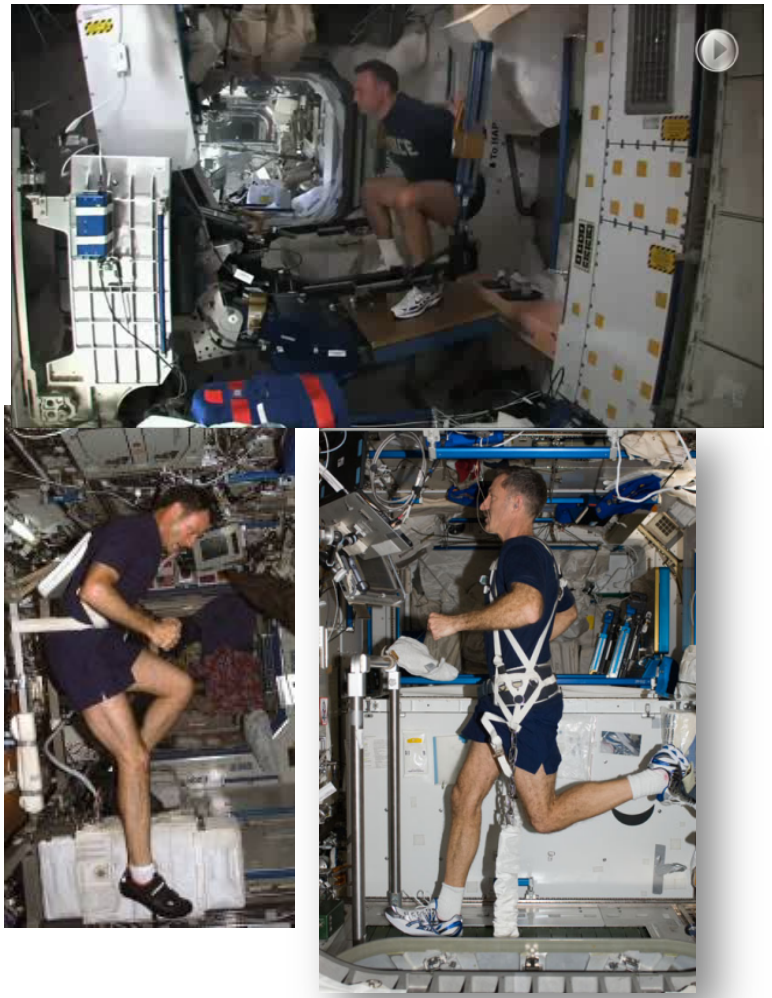


Exercise Countermeasures

Research



Operations



Advanced Exercise Concepts Scope / Authority

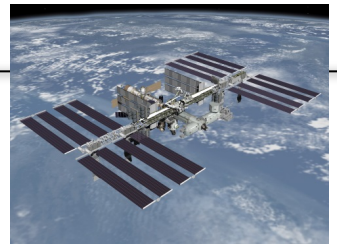
AEC Scope

- **Oversee development** of candidate next generation exercise countermeasures hardware concepts that meet requirements for astronaut health and performance during long duration space missions
- Oversee device Requirements development for candidate systems evaluation (ground and flight)
  - Interpret Astronaut Strength Conditioning and Rehabilitation (ASCR), Exercise Portfolio (EPPf), Bone, Muscle, Sensorimotor, Behavioral Health research findings & inputs ***and translate to functional requirements*** for exercise countermeasures systems for all DRMs
- Perform **Market Surveys and Trade Studies** for current and state-of-the-art technologies
- Manage directed work and solicit technologies through NRAs, SBIRs, Innovation Crowd Sourcing Platforms
- Actively seek and fund **Lessons Learned** from relevant areas including CMS Ops
- Conduct and support **Technology Downselects** and provide recommendations to Human Health Countermeasures (HHC) element management
- Manage development of exercise concepts through TRL 6/7 (ground evaluation/flight validation) demonstrating efficacy and hand over to Programs (e.g., MPCV, ISSP) for subsequent flight development and operations

- Authority is captured in the Human Research Program Plan (HRP 47051C), and Human Research Program Requirements Document (HRP 47052E)

AEC – Multi-Purpose Crew Vehicle (MPCV) and Mars Transit Device Target Performance

ARED – Advanced Resistive Exercise Device



ISS Flight - Operational

MPCV

Mars Transit Vehicle

Device / DRM	ARED/ISS-1 year	MPCV - 21 days	Mars – 1000 days
Mass	~1200 lbm	20 lbm	~120 lbm
Resistive Load	600 lbf	400 lbf	600 lbf
Eccentric Load ?	No	**Yes**	**Yes**
Aerobic ?	No	**Yes**	**Yes**

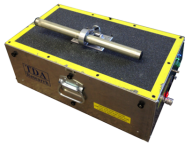
AEC – Multi-Purpose Crew Vehicle (MPCV) and Mars Transit Device Technology Maturation

MPCV EM-2 Mission 2021 and beyond LEO

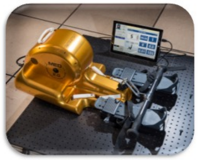
Requirements → MPCV Device Summary and Trade Study Recommendations

MPCV Downselect Process

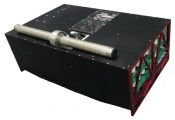
- NASA SBIRs
- Direct Funded Development
- Exercise Industry
- Agency Repurposed Systems
- Bio-Inspired Systems



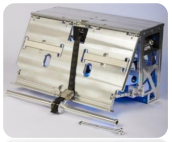
Device for Aerobic and Resistive Training (DART)



Miniature Exercise Device (MED2)



Resistive Overload Combined with Kinetic Yo-Yo (ROCKY)



Orion Flywheel

Cis-Lunar and beyond LEO Mars Transit Vehicle

Requirements → Mars Transit Device Summary and Trade Study Recommendations

Mars Transit Downselect Process

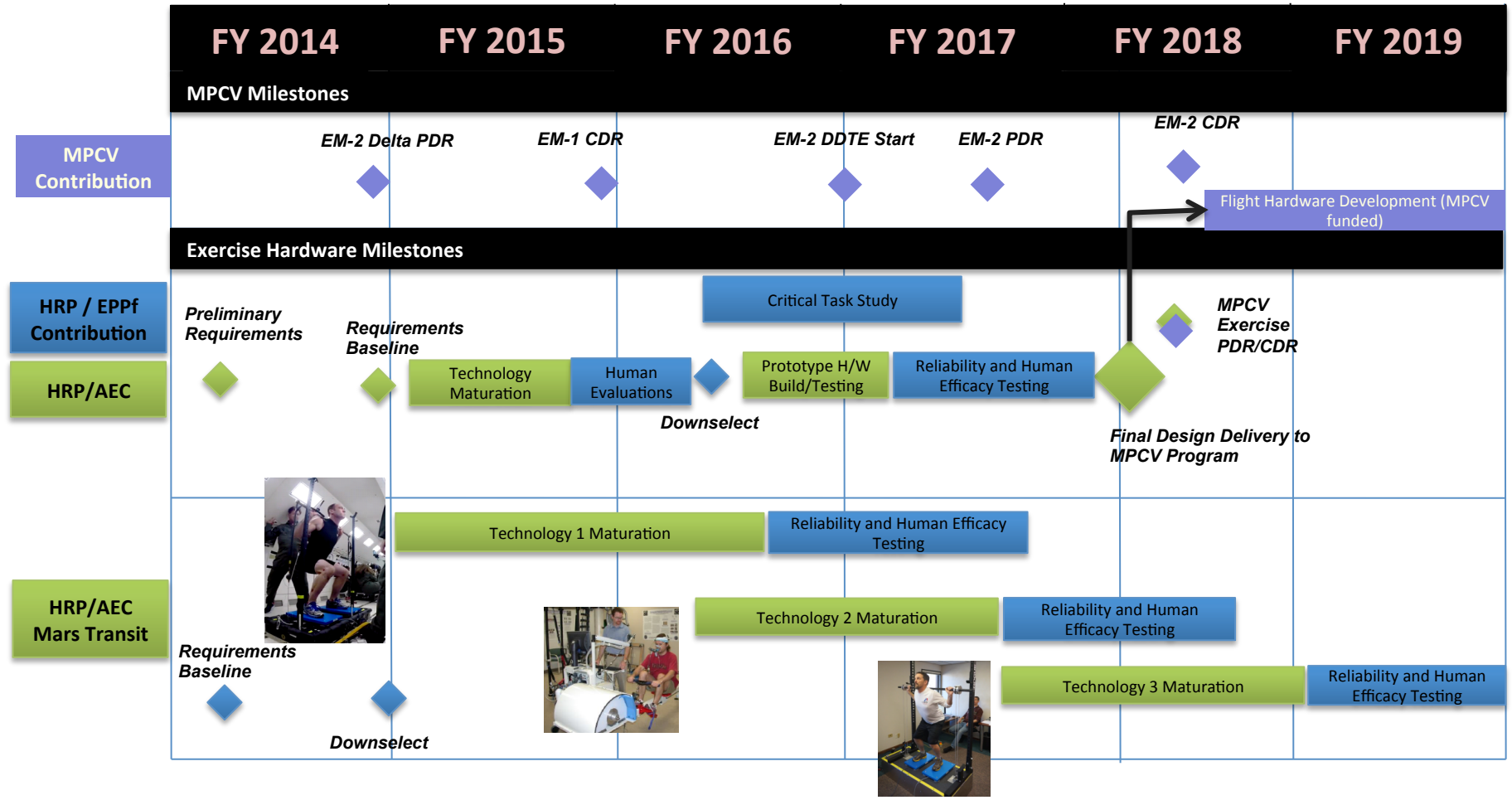
- NASA SBIRs
- Direct Funded Development
- Exercise Industry
- Agency Repurposed Systems

Next Generation Resistive Exercise Device (NGRED)

Hybrid Ultimate Lifting Kit (HULK)

Multi-Mode Exercise Device (M-MED)

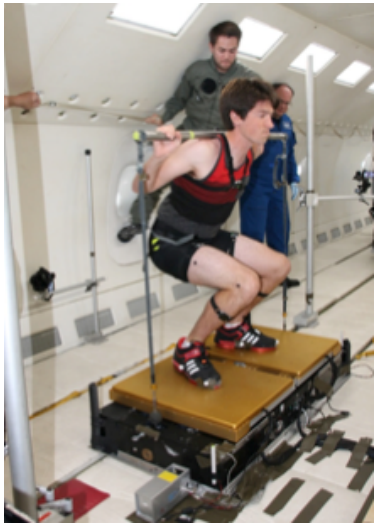
Project Milestones



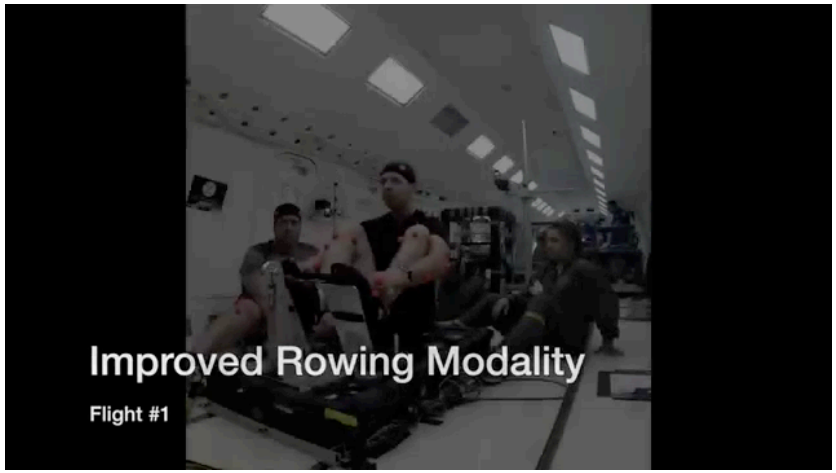
AEC Highlights from the Past Year

Parabolic Flight Testing of MED-2
ISS Program JSC/ER MED-2 Project

Parabolic Flight Testing with HULK
Motion capture Operational Volume Assessment for MPCV



SBIR/Aurora's Enhanced Dynamic Load
Sensor w/ER Force Shoes on HULK platform



Parabolic Flight Testing with HULK
Rowing Exercise

Parabolic Flight Testing with HULK
Squat Exercise

AEC Highlights from the Past Year

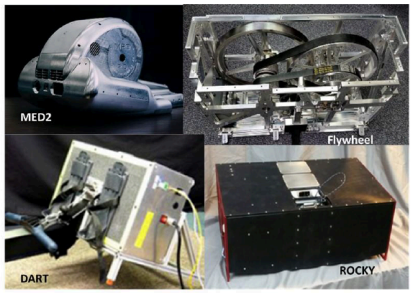
Orion Egress Testing in Neutral Buoyancy Lab

Human in the Loop Testing for MPCV Downselect

Four Exercise Devices Evaluated for EM-2

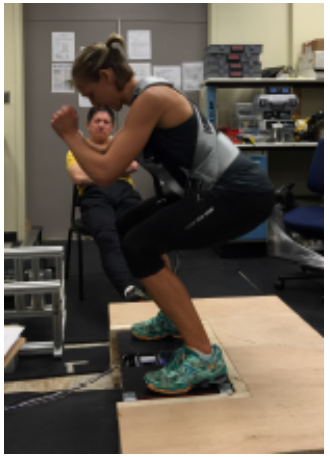
Between October 7 and December 12, 2015, HRP and the JSC Exercise Countermeasures Laboratory evaluated four exercise device concepts for the Orion Exploration Mission (EM-2). The four devices were each evaluated by 10 subjects, totaling 40 individual exercise test sessions over the two months. These human-in-the-loop evaluations will be major criteria for the downselect which will occur in mid-February 2016. The four devices evaluated include: Miniature Exercise Device 2 (MED2) developed by JSC Engineering Directorate, Wyle Flywheel developed by Wyle Laboratories and the JSC Human Health Performance Directorate, Resistive Overload Combined with Kinetic Yo-Yo (ROCKY) developed by Zin Technologies at the Glenn Research Center, and Device for Aerobic and Resistive Training (DART) which was funded by the SBIR Program.

DART - TDA Research

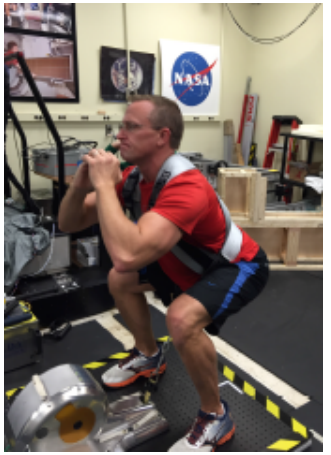


NASA JSC
Exercise Physiology & Countermeasures

Orion Flywheel - Wyle



ROCKY – Zin Technologies



MED-2 – JSC/ER

AEC Highlights from the Past Year

Computer-Controlled Force Generator

TDA Research, Inc.

P.I.: Douwe Bruinsma, Contract#: NNX14CS65P

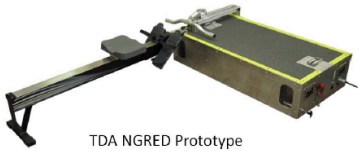
OBJECTIVES

The primary goal of this work was to incorporate rowing functionality into the Next Generation Resistive Exercise Device (NGRED)

The NGRED has the following features
- provide a resistive load from 5 lbf up to 600 lbf
- allows barbell speed of 3.1 m/s
- includes barbell and single-cable interfaces
- automatically adjust to the user's range of motion

In this project we updated the software with a rowing algorithm to simulate a commercial rower

We developed a quick release attachment for the NGRED to function as a rower in parallel contract NNX13C02C

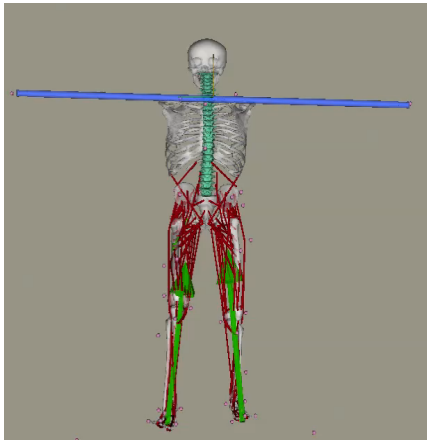


TDA NGRED Prototype
with rowing attachment

Delivery of Phase III Next Generation Resistive Exercise Device

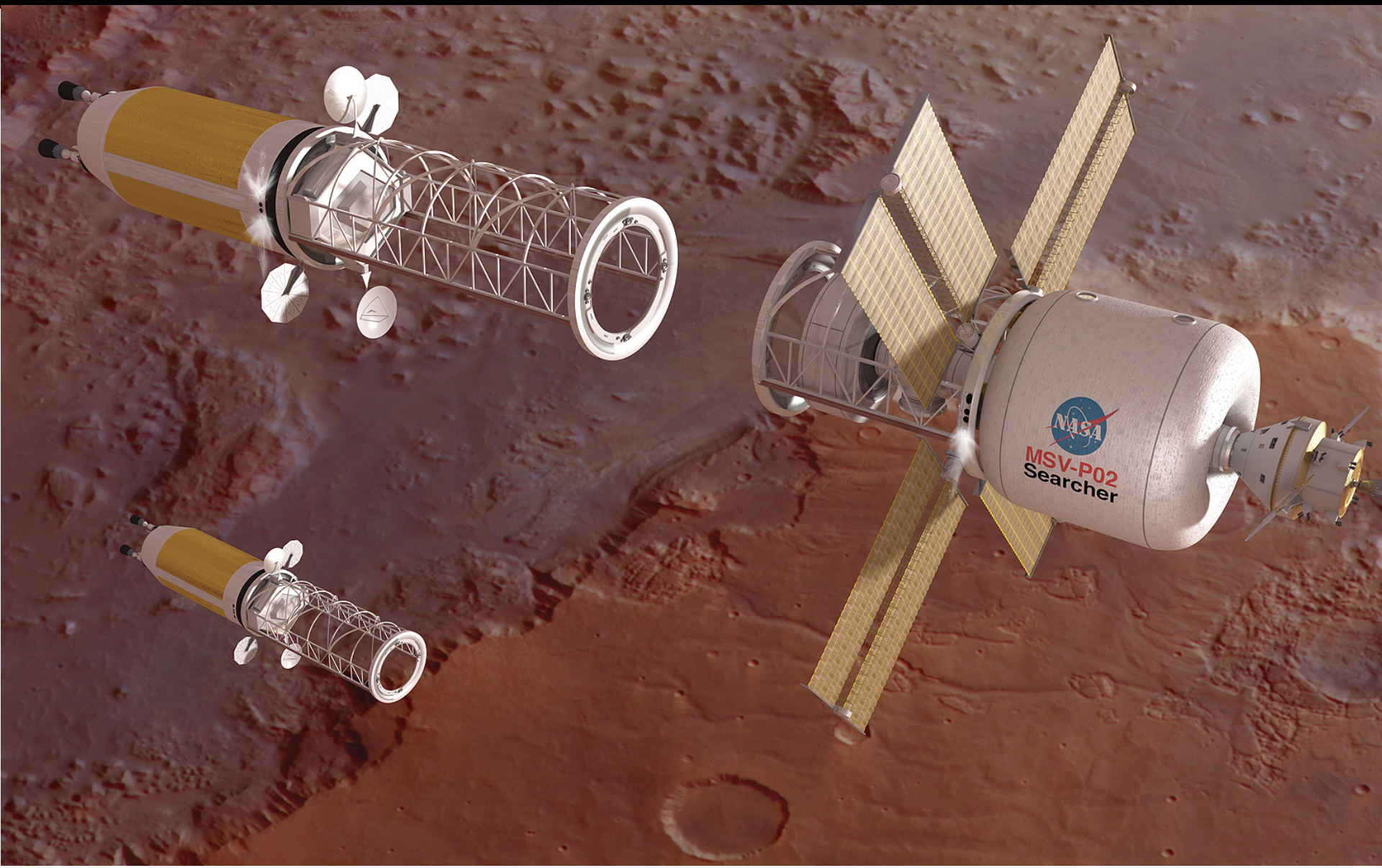
2x2015 Class IE Flight MED-2
SS Program JSC/ER MED-2 Project

MIT Gravity Loading Countermeasure Skinsuit Testing in Exercise Countermeasures Lab (ECL)

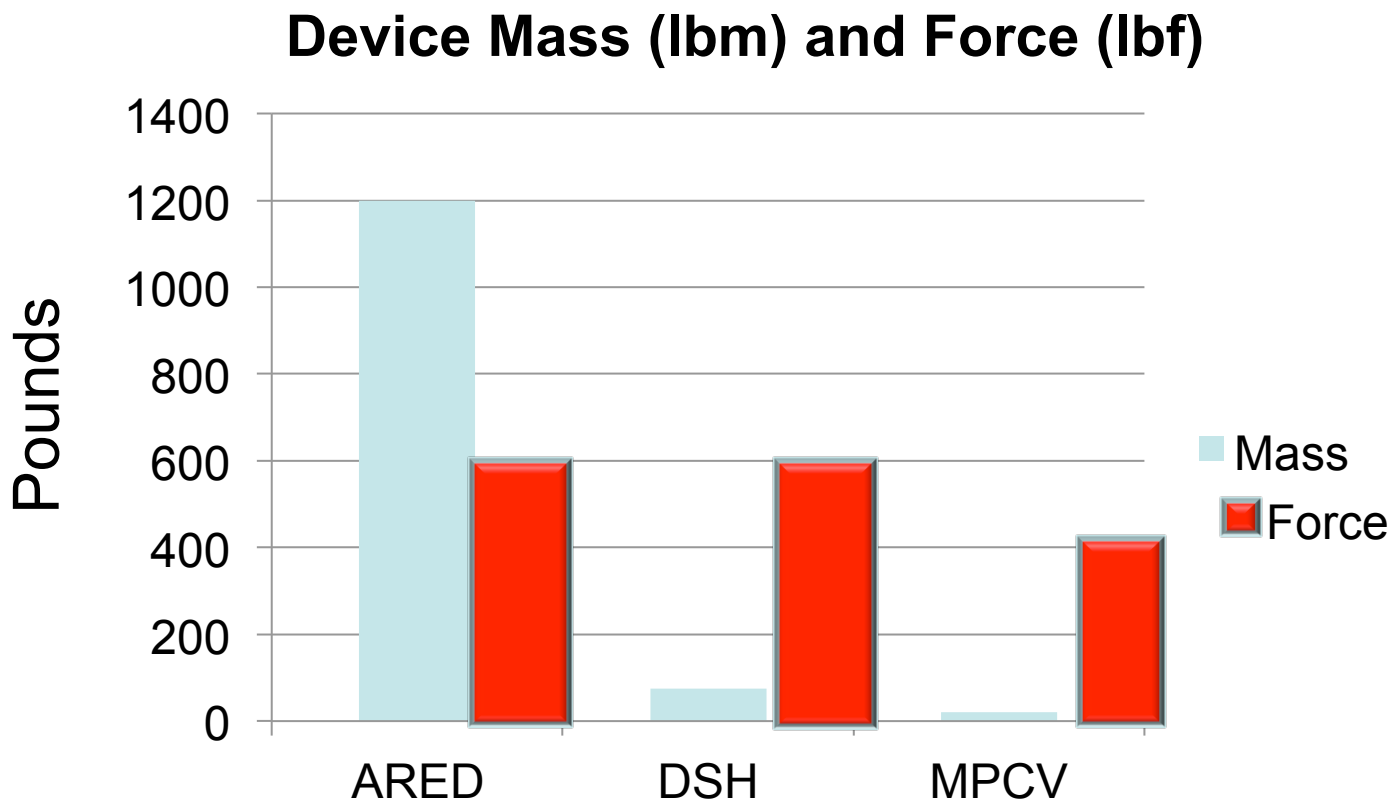


Biomechanical Data Collection with Digital Astronaut Project in Exercise Countermeasures Lab (ECL)

Thank you !



Device Mass and Force Capacity across DRMs



Exercise Countermeasures Laboratory (ECL)

- **Capability:** Exercise Countermeasures Lab
  - Ground analog for simulating human-machine-vehicle interface for Vibration Isolation System verification and,
  - Investigator resource for simulating – zero-g, lunar-g, and Martian-g exercise
  - Human in the loop testing of new concepts

Exercise Countermeasures Lab (ECL)

T2 Treadmill on ISS

Exercise Countermeasures Lab (ECL)